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Secure and reliable patient body motion based authentication approach for medical body area networks

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ABSTRACT

Medical Body Area Network (MBAN) has emerged as a promising solution for monitoring patient activities and actions, and supports a lot of healthcare applications. A MBAN includes a set of sensor nodes deployed such, they can be located on, in, or around the patient body. They are used to monitor physiological signs, which are transmitted then to medical servers without hampering the patient activities. Security is one of the main challenging issues in MBANs since the data nature is highly sensitive. In order to ensure the reliable gathering of patient critical information, it is vital to provide authentication to prevent an attacker from impersonating legitimate sensor nodes. In this paper, we propose a patient body motion based authentication solution. The routine activities, as walking or running, are characterized through a generic model allowing to identify the patient sensor nodes. Through the security analysis, we show its robustness against the well known attacks. In addition, we develop an analytical model to measure the impact of physical and logical attacks on the proposed solution with comparison to the existing protocols. We also evaluate the proposed solution through simulations with respect of important criteria, namely the transmission overhead, response time and energy consumption. The proposed solution demonstrates the best results in performance with comparison to the existing protocols. Furthermore, we have developed a prototype of the proposed solution, where it demonstrates promising results in terms of true acceptation and false rejection.

1. Introduction

Medical Body Area Networks (MBANs) are a major asset in the design of health monitoring applications. They are considered as a promising technology for collecting and gathering physiological signals to monitor the patient health. In MBANs, special nodes are designed as lightweights, miniaturized sensors that could be placed on, in, or around the patient body as tiny intelligent devices. They monitor the patient body and collect different physiological parameters like heart rate, glucose level, blood oxygen level, etc. The collected health information is then transmitted to a local processing unit referred as a sink, which relays them to the hospital or any healthcare system for diagnostic and permanent record. The collected medical data from the sensors must be accessible anytime and anywhere. For instance, the Internet of things (IoT) [1–3] is a well adapted infrastructure for such applications. The MBANs address several challenges in the health sector, such as the medical staff availability, the medical resource limitation, the real time monitoring restriction and the growing health cost. The MBANs have a huge potential to revolutionize the health sector and to provide a comfortable life mode, where

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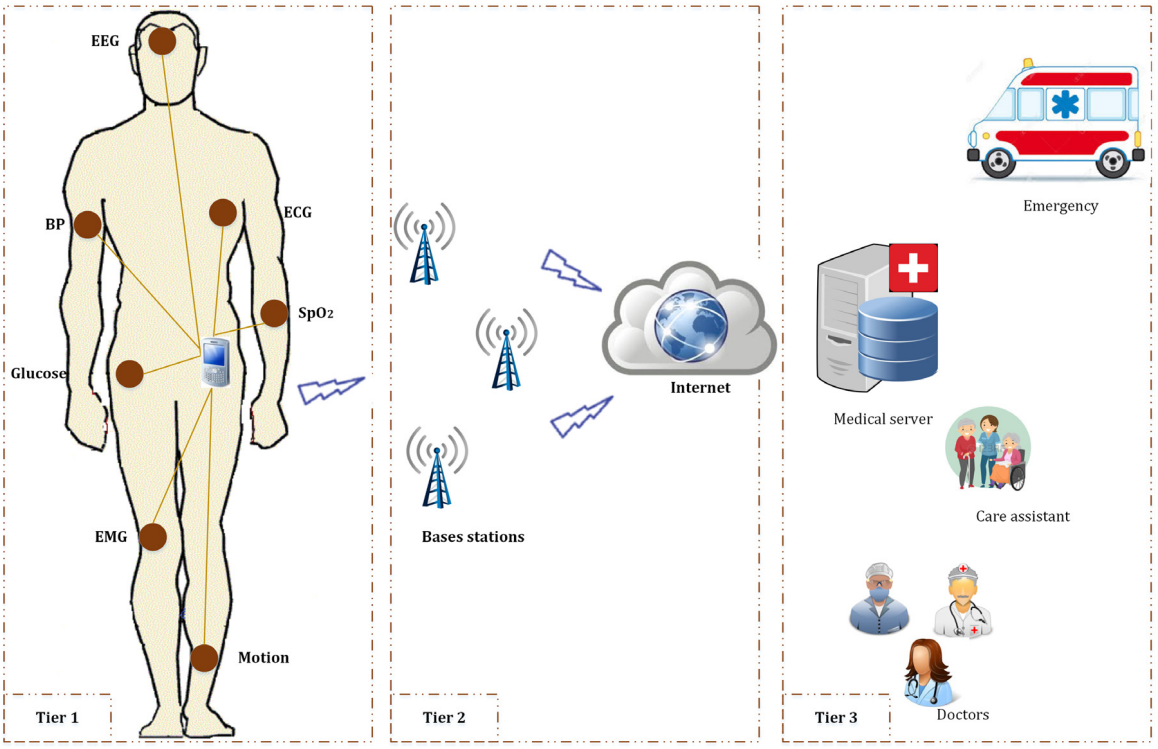

Fig. 1. MBAN general architecture.

the patients are efficiently remote monitored during their daily activities. With MBANs, the emergency aspect is improved, where the pathologies can be detected early, and the health staff has the opportunity to monitor continuously the health status of many patients simultaneously.

MBANs need to stay connected to other networks by using other technologies in order to ensure that the patients data can reach the center of treatment, while the subject is in a different place and the sensed data from the WBAN may ultimately be sent to a centralized healthcare repository for permanent records. Fig. 1 illustrates the MBAN general architecture. A typical MBAN architecture includes the first tier (i) "Intra-MBAN" which refers a small network around the patient body (about 1–2 meters) equipped a gateway (sink) bridging to another network types that can be another node with some routing and data aggregate features, the second tiers (ii) "Inter-MBANs" represent a wide network that can be an Internet network, where the sink forwards the collected data to the base station after processing and aggregation and the third tier (iii) "Extra-MBAN" consists on several applications with server medical or other healthcare personnel. Moreover, MBAN applications span a wide area in the healthcare applications like Patients monitoring indoor Hospital environment, Continuous and Remote healthcare, Real-time home care service with emergency supporting, Body posture analysis in patient-aid rehabilitation, Preventing and managing chronic diseases and Remote assistance and long term monitoring for patient under disabilities, etc. For more details about the research effort in wireless communication standards for healthcare environments, kindly refer to [4–6].

The MBAN applications have emerged as a successful paradigm. Unfortunately, they are subject of novel attack risks [7,8]. Securing MBAN is a serious challenge, which should be rigorously addressed in the healthcare applications, where the managed data is highly sensitive and associated directly to the patient health. Authentication is one of the important security services. In fact, there are several devices in charge to collect physiological parameters about a particular patient and transmit them to a remote server. In order to ensure a reliable gathering of the patient data, it is primordial to authenticate first the legitimacy of the data source devices. Several authentication solutions have been proposed in the literature. Most of the existing solutions are based on cryptographic mechanisms that consume an important part of sensor resources which are more limited in the framework of MBANs. For more information about the research effort of the energy-aware security schemes in such networks, kindly refer to [9].

The rest of the paper is organized as follows. In Section 2, we review some relevant authentication solutions in the framework of MBANs. In Section 3, we present the detailed description of the proposed solution. In Section 4, we analyze the security of the proposed solution. In Sections 5 and 6, we evaluate its efficiency through modeling, simulations and practical experiments. Finally, we conclude the paper in Section 7.

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